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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Image processing; texture; edge detection.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes progress made under support of the grant; [illegible] image segmentation algorithm called MITES; and recovering the [illegible] orientation of a planar textured surface from an image of that surface.

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1. RESEARCH OBJECTIVES

This is the final report for Air Force Grant AFOSR-81-0080. This grant was a logical continuation of Contract F49620-80-C-0043. The main research objectives of the project included:

1) Developing formal models for the detection of local features, such as edges, in natural textures.

2) Developing image segmentation models based on the spatial distributions of texture features in an image, and

3) Conducting empirical studies of the theoretical models developed in (1) and (2) to the analysis of natural textures.

2. FINAL STATUS OF THE RESEARCH PROJECT

The contributions in image texture analysis achieved during the first 24 months of this research program are documented in the final report for Contract F49620-79-C-0043. During the past 12 months we have concentrated on two research problems:

1) During 1980-1981 we developed an image segmentation algorithm called MITES. MITES is an iterative algorithm which performs non-linear smoothing of texture features based on determining, for each pixel in an image, whether that pixel is interior to a uniformly textured region, or is on an edge

between two differently textured regions. We were able to successfully segment a variety of images containing several differently textured regions.

The MITES algorithm was computationally very expensive, because at each iteration one had to determine, for each pixel, whether that pixel was interior to a textured region or an edge pixel. This required a significant number of computations per pixel. Therefore, we decided that it would be worthwhile to investigate a parallel version of MITES. (Actually, MITES is, in principle, a parallel algorith, but at the pixel level; for practical purposes, one would like to break the picture into blocks, and analyze a complete block.)

Therefore, in [1], Mitiche and Davis investigated an extension of a local thresholding algorithm first proposed by Chow and Kaneko [2]. This algorithm is based on a regular decomposition of the image into square blocks. Segmentations are computed for a subset of these blocks, and then the segmentations for these blocks are "interpolated" into the remaining blocks. In the original Chow and Kaneko paper, the segmentation was computed by a thresholding operation. In the experiments which we reported in [1], a thresholding segmentation operator was also used, but the control of this operator was

designed so that a variable, rather than fixed, resolution grid of blocks were the domains of the segmentation processes.

In [1] we describe the results of applying the algorithm to a variety of images (mostly containing textures composed of large, noisey primitives). In the future, this would should be extended to utilize the MITES segmentation algorithm as the segmentation process.

2) During the past year, we have started to give a considerable amount of attention to the problem of recovering the three-dimensional orientation of a planar textured surface from an image of that surface. When analyzing images of uniformly textured three-dimensional planar surfaces one would not expect their images to be uniformly textured because of forshortening and distance effects. If we ignore distance effects (by assuming a parallel projection), then one can concentrate on recovering surface orientation from textured based on an analysis of the effects of the projection operator on surface textural features. In a recent paper, Witkin [3] suggested that the non-uniformities that one observes in images of textured surfaces are mostly due to the projection operation. More specifically, Witkin related the tilt of the surface to the distribution of gradient directions on the surface, and assumed that deviations from a uniform observed distribution of gradient directions in the image

of a texture are a result of projection. Thus, one must determine how a uniform distribution of directions is transformed by the projection operation. Once this transformation is determined, then one can pose the problem of recovering the surface orientation of a small planar patch of texture based on observing the distribution of directions of gradients in an image as a maximum likelihood problem.

We have been studying several very efficient computational procedures for solving (approximations) to the maximum likelihood problem. Furthermore, we have been investigating other approaches to modelling the texture on a planar surface so that the effects of projection can be analyzed. Since this work was in progress at the termination of the grant, there are no written reports which describe the work. The work is currently being continued under a different source of support at the Computer Vision Laboratory, University of Maryland, College Park, MD.

REFERENCES

1. A. Mitiche and L. S. Davis, "Local Thresholding Using Convergent Evidence," University of Texas LIRA TR-81-4, June 1981.

2. C. K. Chow and T. Kaneko, "Automated Boundary Detection of the Left Ventricle from Cineangiograms," Comp. Biomedical Res., 5, 1972, 388-410.

3. A. P. Witkin, "Recovering Surface Shape and Orientation from Texture," Artificial Intelligence, 17, 1981, 17-45.

3. WRITTEN PUBLICATIONS (which appeared or were accepted for publication during the past 12 months)

1. A. Mitiche and L. S. Davis, "Local Thresholding Using Convergent Evidence," University of Texas LISA TR-81-4, June 1981.

2. L. S. Davis and L. S. Davis, "MITES: A new tool of image segmentation," accepted for publication in Computer Graphics and Image Processing.

3. A. Mitiche and L. S. Davis, "Finding Edges in Natural Textures," accepted for publication in Signal Processing.

4. PROFESSIONAL PERSONNEL

1. Larry S. Davis, Associate Professor and Principal Investigator.

2. Amar Mitiche, Graduate Research Assistant (Ph.D. granted, May, 1981).

3. Davis Harwood, Graduate Research Assistant.

4. Larry Mahaffey, Graduate Research Assistant.

5. INTERACTIONS

1. Delivered lecture, "A survey of texture analysis" at NASA Johnson Space Center, June 1981.